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(71) Applicant: ALCATEL  
75008 Paris (FR)

(72) Inventor: Bhatia, Jagieet

Simi Valley, California (US)

(74) Representative: Schäfer, Wolfgang, Dipl.-Ing.  
Dreiss, Fuhendorf, Steimle & Becker  
Postfach 10 37 62  
70032 Stuttgart (DE)

### (54) Method and system for increasing available user VLAN space

(57) A method and system for conserving VLAN identifier (VID) space in a metropolitan area network (MAN) that transmits data between a plurality of network sites for a plurality of customers, one or more of the customers using tagging to construct a plurality of VLANs. In the preferred embodiment, a first MAN switch marks each customer's untagged traffic with a VLAN identifier conserving (VIC) tag prior to transmitting the traffic

through the MAN. The VIC tag, preferably an 802.1Q tag includes a dedicated Ethertype, i.e., a VLAN protocol identifier (VPIID), different than the VPIID 0x8110 used with the customers' VLAN tagged traffic or with the metro tag used to tunnel the customers' traffic through the MAN. The VIC obviates the need to assign a VID for each customer's untagged traffic that propagates through the MAN, thereby making a plurality of VID available for customers.

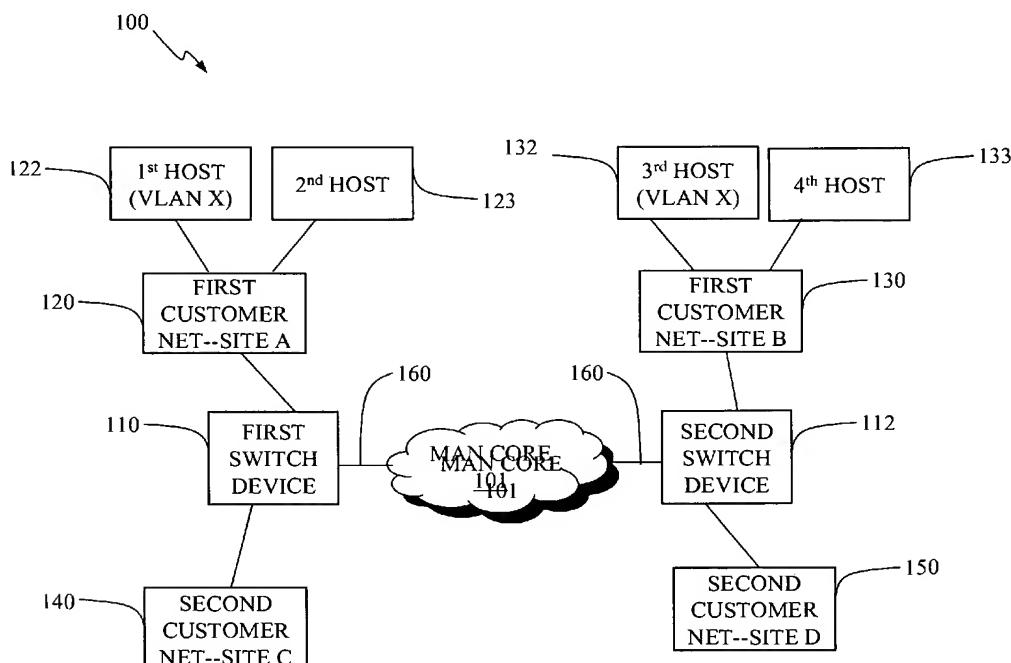


FIG. 1

## Description

### FIELD OF INVENTION

**[0001]** The invention generally relates to a protocol for increasing the VLAN space available to customers of a metropolitan area network, for example, by specially tagging untagged traffic, i.e. non-VLAN traffic, propagated through the network. In particular, the invention relates to a system and method for employing a unique VLAN identifier conservation (VIC) tag to distinguish each customer's untagged traffic from the traffic of other customers without employing a VLAN identifier from the total VLAN space available for customers.

### BACKGROUND

**[0002]** US patent no. 6,618,388 to Yip et al. discloses a system for distributing data of a metropolitan area network (MAN) that interconnects customers and resources across a geographic area or region. Yip employs a VMAN tag to isolate the traffic of each customer from that of the other customers in the MAN core. In particular, the customer traffic is encapsulated with a VMAN tag in the form of an 802.1Q tag comprising a VLAN protocol identifier (VPIID) equal to 8181 and a unique VLAN identifier (VID) assigned to each customer. The VMAN tag is applied when the customer traffic enters the MAN core and then removed upon leaving the MAN core. While the Yip protocol can transport customers' VLAN tagged and untagged traffic, it requires that each of the switches in the path through the MAN core be enabled with this proprietary protocol in order to recognize and process the 8181-tagged frames. There is therefore a need for a new protocol to securely distribute tagged and untagged traffic of customers using existing networks unaware of the YIP tag protocol.

### SUMMARY

**[0003]** The preferred embodiment of the present invention features a method and system for effectively increasing the available VLAN space, i.e. VID value space, in a network adapted to transmit data originating from a plurality of networks, the plurality of networks comprising a first network and a second network, wherein the first network comprises a first untagged domain and a first VLAN domain associated with a first VID space, and the second network comprises a second untagged domain. The method preferably comprises the steps of tagging one or more PDUs from the first untagged domain with a VLAN identifier conservation (VIC) tag comprising a VID associated with the first network, and tagging one or more PDUs from the second untagged domain with a VIC tag comprising a VID associated with the second network. The VIC tag, preferably and 802.1Q tag, includes a novel VPIID different than the 0x8100 value conventionally used to identify

the presence of a VLAN data. Using the novel VPIID, untagged traffic from various sources can be distinguished without the need of a dedicated VIDs selected from the 0x8100-tag VID value space. In this manner, a

- 5 metropolitan area network (MAN) service provider may transport the untagged traffic of a plurality of customers without removing a VID from the VID space set aside for customers, thereby making more VIDs available for actual VLAN traffic in the customer networks. Both the
- 10 standard 802.1Q tagged frames and novel VIC-tagged frames may then be encapsulated with a metro tag used to securely tunnel the traffic across the MAN core.

### BRIEF DESCRIPTION OF THE DRAWINGS

- 15
- [0004]** The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings, and in which:
- 20 FIG. 1 is a metro area network with which the metro switching device may be employed, according to the preferred embodiment of the present invention;
- 25 FIG. 2 is a functional block diagram of a metro switching device, according to the preferred embodiment of the present invention;
- 30 FIG. 3 is a flowchart of the process by which a metro switching processes traffic entering the MAN, according to the preferred embodiment of the present invention;
- 35 FIG. 4 is a flowchart of the process by which a metro switch processes traffic received from the MAN core, according to the preferred embodiment of the present invention;
- 40 FIG. 5A is a diagram of an untagged Ethernet frame;
- 45 FIG. 5B is a diagram of an Ethernet frame with a generic tag having the structure of an 802.1Q tag;
- 50 FIG. 5C is a diagram of an Ethernet frame with a metro tag and VIC tag, according to the preferred embodiment of the present invention; and
- 55 FIG. 5D is a diagram of an Ethernet frame with a metro tag and standard 802.1Q tag, according to the preferred embodiment of the present invention.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

- 50
- [0005]** Illustrated in FIG. 1 is a metropolitan area network (MAN) with which the preferred embodiment of the metro labeling protocol may be implemented. The MAN 100 comprises a MAN core 101, a plurality of metro switches 110, 112 at the edge of the MAN core 101, and one or more customer networks 120, 130, 140 and 150, and various end stations 122, 123, 132, 133. The MAN 100 and particularly the MAN core 101 comprise one or

more network nodes for switching protocol data units (PDUs) between various customer networks 120, 130, 140, 150 based on layer 2 through layer 7 protocol stacks, as defined by the Open Systems Interconnect (OSI) reference model. The switches in the MAN core 101 may further include one or more packet-switched or circuit switched systems employing, for example, Internet Protocol (IP), asynchronous transfer mode (ATM), frame relay, synchronous optical network (SONET), integrated services data network (ISDN), X.25, Ethernet, Token Ring, or a combination thereof.

**[0006]** The MAN core 101 and metro switches 110, 112 are typically operated by a metro service provider that contracts with various customers by way of service level agreements (SLA) to provide network services including high speed data, long-haul transport and traffic flow aggregation, for example. Each of the customer networks generally include customer-premise equipment (CPE) distributed across one or more customer sites, the various sites of each customer being operatively coupled by means of the MAN 100. A first customer network, for example, comprises a first network site A 120 and a second network site B 130, while a second customer network comprises a first network site C 140 and a second network site D 150. The customer networks generally include one or more local area networks (LANs), but may also include or operatively couple to the Internet, an intranet, another metropolitan area network (MAN), a wide area network (WAN), or a combination thereof.

**[0007]** The customer networks comprise various network devices including, for example, one or more bridges, switches, and routers that operatively couple various local end stations. In the preferred embodiment, one or more of the network devices are VLAN-aware device, preferably enabled with a VLAN tagging protocol such as Institute of Electrical and Electronic Engineers (IEEE) 802.1Q standard. These VLANs may be localized within a single customer network site or span across multiple customer network sites. In the first customer network, for example, the first customer network at site A 120 includes a first host 122 in a VLAN-aware domain, namely VLAN-X. A separate site of the same customer, first customer network at site B 130, includes a third host 132 also in VLAN-X. The service provider must therefore securely transmit VLAN-X traffic between site A 120 and site B 130 while limiting distribution to the appropriate VLAN member set. In addition to VLAN traffic, the MAN 100 must also distribute untagged, i.e. no-VLAN, traffic between various customer network sites including, for example, a second host 123 in a VLAN-unaware domain at site A 120 and a fourth host 133 in another VLAN-unaware domain at site B 130.

**[0008]** Tunneling is generally employed to distribute VLAN traffic and untagged traffic between various sites in the customer network in a manner that is transparent to the customer. To tunnel traffic through the MAN 100, the service provider uses one or more markers, prefer-

ably labels or tags appended to the protocol data units (PDUs) in transit between the various sites of a customer. A tag used in the MAN core 101, referred to herein as a metro label, is generally inserted into the PDU at

- 5 the point of ingress into the MAN core 101, e.g. metro switch 110, and the metro label removed at the point of egress, e.g. metro switch 112. Inside the MAN core 101, the metro label of an ingress PDU is inspected upon receipt at a switch, the next hop identified based in the metro label, and the PDU retransmitted from the appropriate egress port. Switching on a label is generally faster and more efficient than performing OSI layer 3 routing logic.

**[0009]** The service provider's metro label is separate  
15 from the VLAN tag used by a customer in the associated customer network. The customer VLAN tag (CT) is generally appended to VLAN traffic in the customer network using an identifier selected from a particular VLAN space comprising a set of VLAN identifier (VID) values.

- 20 To differentiate the traffic of the various customers, the service provider generally assigns each customer a set of one or more unique VID values. In the case of a 802.1Q tag, the VLAN space is selected from the 4094 VIDs available for use. In addition to differentiating traffic  
25 within a customer's network, the customer's VLAN tag also servers to differentiate its VLAN traffic from the VLAN traffic of every other customer of the service provider within the MAN core 101.

**[0010]** While the VID assignments effectively distinguish customer VLAN traffic, another mechanism is needed to differentiate the various customers' untagged traffic in the MAN core 101. In some contemporary approaches, the service provider appends the customer's untagged traffic with a VLAN tag where the customer tag might otherwise be. The VID value for this tag is generally selected from the VLAN space set aside for the particular customer. This selection approach presents at least two challenges. In particular, the customer network may have an existing VLAN addressing scheme in

- 30 which the VID is already assigned. Even if the VID is available within the customer's network, assigning a VID for each customer's untagged traffic effectively reduces the available address space and therefore reduces the number of customers that may be support by the service provider. As explained in greater detail below, the present embodiment of the invention introduces a new VLAN tag type specifically for untagged traffic, thereby enabling the metro service provider to be effectively transparent to all customers with untagged traffic.

**[0011]** Illustrated in FIG. 2 is a functional block diagram of a representative metro switching device with which the invention may be implemented. The switching device 110 may be one of a plurality of metro switches operably coupled to the MAN core 101 via shared communications links 160 and operably coupled to a plurality of customer networks. The switching device 110 of the preferred embodiment comprises one or more network processors 230 and a plurality of network interface

modules (NIMs) 220, 222. Each of the NIMs 220, 222 includes at least one external port operatively coupled to a communications link for purposes of receiving ingress data traffic and transmitting egress data traffic. The metro switch 110 is generally capable of, but not limited to, layer 2 through layer 7 switching operations as defined in the Open Systems Interconnect (OSI) reference model. The metro switch 110 is a VLAN tag-aware switch, preferably enabled with the IEEE 802.1Q standard operating in conjunction a transmission control protocol (TCP)/IP or user datagram protocol (UDP)/IP protocol suite.

**[0012]** The network processor 230 preferably comprises a forwarding processor 232, an data link layer address table 240, a filter module 242, a VLAN association module 244, a network layer forwarding table 250, and a policy database 252. Upon receipt of a PDU, the forwarding processor 232 inspects the PDU for address information to determine how to process the PDU. In the case of a unicast frame, for example, the forwarding processor 232 searches for the destination address of frame in the address table 240 to determine the port to which that address maps. The forwarding processor 232 may also consult the filter module 242 to determine if the VLAN tag information of an incoming frame is properly associated with the inbound port. If the incoming frame is not in the VLAN member set associated with the port, the frame is filtered. Similarly, the filter module 242 may also filter outgoing frames prior to transmission from the egress ports if those frames are not a member set of the VLAN associated with the outgoing frame.

**[0013]** In the case of routing operations, the forwarding processor 232 is adapted to de-encapsulate ingress PDUs, inspect the addressing information contained therein, determine the next-hop based on a search of the forwarding table 250, and generate a new data link layer header. The Quality of Service (QoS) and or Class of Service (CoS) applied to the new frame is generally determined from the policy database 252 for purposes of buffering and scheduling the PDU for transmission out via the egress port or into a switch fabric (not shown).

**[0014]** In addition to regulating the distribution of VLAN traffic to the proper ports, the VLAN association module 244 also supports VLAN tagging operations in the switching device 110. The VLAN associate module 244 enables the switching device 110 to recognize a PDU received from a customer network, determine if the PDU is to be transmitted through the MAN core 101, and provide one or more tags to securely tunnel through the MAN core 101. The VLAN associations rules embodied in module 244 may be based on the ingress or egress port number, the source or destination media access control (MAC) address, the customer VLAN tag, or a combination thereof.

**[0015]** Illustrated in FIG. 3 is a flowchart of the process by which a metro switching processes traffic entering the MAN. Upon receipt of a PDU from the customer network (step 310), the metro switch, e.g.; first switching

device 110, determines where the PDU is to be transmitted. If the first customer network is operatively coupled to a plurality of ports at the first switching device 110, the PDU may be transmitted locally (step 320) to

- 5 one or more end nodes that are reachable through the switching device 110. The nodes may be reached by switching the PDU to nodes identified in the address table 240 or routing the PDU to nodes identified in the forwarding table 250. If the PDU is destined for another site in the customer network reachable through the MAN core 101, the MAN core testing step 330 is answered in the affirmative and the tag state of the PDU determined.
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**[0016]** If the PDU already possesses one or more VLAN tags, the CT testing (step 340) is answered in the

- 15 affirmative. The PDU generally includes a VLAN tag if, for example, the frame originated from a first host 122 in a VLAN tagged domain. The PDU in the preferred embodiment is an Ethernet frame and the VLAN tag is an 802.1Q tag with a VID defined by the customer. If the PDU received from the particular customer is untagged, CT testing step 340 is answered in the negative and a VLAN identifier conservation (VIC) tag inserted (step 350) in the untagged frame by the VIC label module 234 in the forwarding processor 232 of the first switching device 110. Using the VLAN association rules defined by
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the service provider and maintained in the VLAN association module 244, the first switching device 110 constructs the VIC tag comprising a unique VPID different than the standard 0x8100, preferably a VPID of 0x8900 or comparable value. The VIC tag may further comprise a VID in the form of a customer identifier (CID) that uniquely identifies the particular customer from the other service provider customers. An Ethernet frame with a VIC tag produced in VIC tagging (step 330) is preferably consistent with the frame 500B of FIG. 5B discussed below.

**[0017]** In the preferred embodiment, generally all traffic transmitted to the MAN core 101 by the service provider also includes a metro label, independent of whether the PDU possesses a VLAN tag or VIC tag. The outer metro label appended to the PDU (step 360) in the form of an 802.1Q tag preferably includes a VPID equal to 0x8100 and a VID signifying that the traffic is that of the service provider. When transmitted into the MAN core

- 40 101 (step 370), an Ethernet frame corresponding to the previously-untagged traffic is represented by the VIC-tagged frame 500C of FIG. 5C while the customer traffic with the customer's VLAN tag is represented by the VLAN-tagged frame 500D of FIG. 5D. One skilled in the art will recognize that the order in which a tunnel tag is inserted into a PDU relative to either a VLAN tag or a VIC tag is immaterial so long as the relative placement of the tags is preserved.
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- 50

**[0018]** Illustrated in FIG. 4 is a flowchart of the process by which a metro switch processes traffic received from the MAN core. The metro switch that receives traffic from the MAN core, e.g. second switching device 112 in the preferred embodiment, is substantially similar to the

first switching device 110. Upon receipt of a PDU from the MAN core 101 (step 410), the second switching device 112 removes (step 420) the outer metro label used to tunnel through the MAN core 101. The second switching device 112 also determines, in the inner tag testing (step 430), whether the PDU possesses a tag in the form of a VLAN tag or a VIC tag. If an inner tag is present, the switching device 112 consults the VLAN association module 242 to determine (step 440) from the customer VLAN tag or the CID of the VIC tag which port(s) are to receive the PDU. The filter module 242, e.g. an egress filter, causes the PDU to be discarded (step 450) at those ports not associated with the associated VLAN or associated untagged domain. If the port is included in the VLAN member set, however, the port association testing (step 440) is answered in the affirmative and the second switching device 112 determines the character of the inner tag. If the inner tag is a VIC tag, the VPID testing (step 460) is answered in the affirmative and the switching device 112 removes the VIC tag (step 470) and forwards (step 480) the untagged frame to the untagged domain reachable through the associated port. If the inner tag is a customer VLAN tag, the VPID testing (step 460) is answered in the negative and the PDU forwarded (step 480) to the appropriate VLAN domain with the VLAN tag intact.

**[0019]** Illustrated in FIG. 5A-5D is a plurality of PDUs at various stages of processing in accordance with the preferred embodiment. Illustrated in FIG. 5A, in particular, is a diagram of a representative data link layer PDU. The untagged Ethernet frame 500A generally includes a frame header comprising a destination MAC address 501, a source MAC address 502, and a frame type field 504 to indicate the client protocol running on top of the Ethernet including, for example, network layer protocols such as Internet Protocol (IP), IPX, and APPLETALK of Apple Computer, Inc., Cupertino, California. The data carried by the frame is then embedded in the payload field (PYLD) 506 along with the header information of higher layer protocols. At the terminal end of the frame is the frame check sequence (FCS) field 508 used to by the receiving device to detect transmission errors.

**[0020]** Illustrated in FIG. 5B is a diagram of a representative data link layer PDU with a first tag. If the Ethernet frame 500B is generated in a VLAN tagged domain within the customer network, the first tag is a generally a VLAN tag inserted at the source node or other customer network device. If the PDU originates from within an untagged domain in the customer network, however, the Ethernet frame 500B includes a novel tag referred to herein as a VLAN identifier conservation (VIC) tag 510. The VIC tag 510 in the preferred embodiment has the structure and placement of an 802.1Q tag 510, but a novel VLAN protocol identifier (VPIID) 512 to distinguish PDU 500B from other VLAN tagged traffic transmitted by the service provider through the MAN core 101. In particular, the modified-802.1Q VIC tag 510

inserted between the source address 502 and the type field 520 comprises a 16-bit VPIID 512 having a value reserved by the service provider for purposes of distinguishing each customer's tagged traffic from its untagged traffic. In the preferred embodiment, the VPIID 512 has a value of 0x8900, although one skilled in the art will recognize that this value need only be distinguishable from other reserved VPIIDs and distinguishable from any other VIC tag VPIIDs reserved by other service providers. The term "reserved" as used herein presumes that the IEEE Type Field Registrar or other regulatory body has not assigned the value for a different purpose.

5 **[0021]** In addition to the VPIID 512, the VIC tag 510  
 10 may further include a tag control information (TCI) field comprising a 3-bit priority field 514 indicating the user priority of the field, a canonical format indicator (CFI) 516 indicating the bit ordering of the bytes within the frame, and a 12-bit customer identifier (CID) 518 defining the particular customer or traffic flow with which the frame is associated. In the preferred embodiment, the CID takes the place of the VID used in the 802.1Q tag.  
**[0022]** One of many advantages of the VIC metro tagging scheme is that it obviates the need to employ a conventional VLAN tag and expend a VLAN identifier (VID) value for each customer's untagged traffic that propagates through the metro core 101. That is, without the VIC tag, the untagged metro traffic of each of the plurality of customers would generally require a conventional

15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 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5230 5235 5240 5245 5250 5255 5260 5265 5270 5275 5280 5285 5290 5295 5300 5305 5310 5315 5320 5325 5330 5335 5340 5345 5350 5355 5360 5365 5370 5375 5380 5385 5390 5395 5400 5405 5410 5415 5420 5425 5430 5435 5440 5445 5450 5455 5460 5465 5470 5475 5480 5485 5490 5495 5500 5505 5510 5515 5520 5525 5530 5535 5540 5545 5550 5555 5560 5565 5570 5575 5580 5585 5590 5595 5600 5605 5610 5615 5620 5625 5630 5635 5640 5645 5650 5655 5660 5665 5670 5675 5680 5685 5690 5695 5700 5705 5710 5715 5720 5725 5730 5735 5740 5745 5750 5755 5760 5765 5770 5775 5780 5785 5790 5795 5800 5805 5810 5815 5820 5825 5830 5835 5840 5845 5850 5855 5860 5865 5870 5875 5880 5885 5890 5895 5900 5905 5910 5915 5920 5925 5930 5935 5940 5945 5950 5955 5960 5965 5970 5975 5980 5985 5990 5995 6000 6005 6010 6015 6020 6025 6030 6035 6040 6045 6050 6055 6060 6065 6070 6075 6080 6085 6090 6095 6100 6105 6110 6115 6120 6125 6130 6135 6140 6145 6150 6155 6160 6165 6170 6175 6180 6185 6190 6195 6200 6205 6210 6215 6220 6225 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9230 9235 9240 9245 9250 9255 9260 9265 9270 9275 9280 9285 9290 9295 9300 9305 9310 9315 9320 9325 9330 9335 9340 9345 9350 9355 9360 9365 9370 9375 9380 9385 9390 9395 9400 9405 9410 9415 9420 9425 9430 9435 9440 9445 9450 9455 9460 9465 9470 9475 9480 9485 9490 9495 9500 9505 9510 9515 9520 9525 9530 9535 9540 9545 9550 9555 9560 9565 9570 9575 9580 9585 9590 9595 9600 9605 9610 9615 9620 9625 9630 9635 9640 9645 9650 9655 9660 9665 9670 9675 9680 9685 9690 9695 9700 9705 9710 9715 9720 9725 9730 9735 9740 9745 9750 9755 9760 9765 9770 9775 9780 9785 9790 9795 9800 9805 9810 9815 9820 9825 9830 9835 9840 9845 9850 9855 9860 9865 9870 9875 9880 9885 9890 9895 9900 9905 9910 9915 9920 9925 9930 9935 9940 9945 9950 9955 9960 9965 9970 9975 9980 9985 9990 9995 9999 10000 10005 10010 10015 10020 10025 10030 10035 10040 10045 10050 10055 10060 10065 10070 10075 10080 10085 10090 10095 10100 10105 10110 10115 1

signed a unique identifier.

**[0024]** Illustrated in FIG. 5D is a diagram of representative data link layer PDU with a VLAN tag and tag. The Ethernet frame 500D represents a conventional VLAN-tagged frame into which an outer metro tag 530 is inserted for transmission through the MAN core 101. The VLAN tag is preferably a conventional 802.1Q tag 540 with a VPID equal to 0x8100 and a first VID value, VID1 548, selected from the range of VIDs allocated by the service provider for the use of the particular customer. The metro tag 530 is consistent with that described above for the untagged traffic.

**[0025]** In the preferred embodiment, the term "customer" user herein represents one example of a logical group association of packets. In addition to the packets associated with a particular customer, a logical group association may also refer to some other logical relation including a subgroup within an enterprise such as an engineering department, management, accounting, or legal.

**[0026]** The following method/s and/or method steps, separately or in combination, constitute further advantageous embodiments of the claimed and/or described invention:

- The claimed and/or described method, wherein the metro tag is an outer tag with respect to a VIC tag;
- The claimed and/or described method, in a second MAN switch, wherein the method further comprises the steps of: receiving one or more PDUs with a metro tag and a VIC tag; removing the metro tag and the VIC tag; and transmitting untagged PDUs within the associated customer network;
- A method for preserving a logical group association of packets transmitted over a communication network having multiple logical groups, comprising the steps of: determining a VLAN tag state of a packet; and applying a VLAN tag to the packet in response to the determination, wherein the VLAN tag includes a VLAN protocol identifier reserved for untagged packets;
- The claimed and/or described method, wherein the VLAN tag further includes an identifier of a logical group to which the packet belongs;
- The claimed and/or described method, further comprising the steps of: reviewing the VLAN tag; and forwarding the packet on a port associated with the logical group in response to the review;
- A method for transmitting a plurality of PDUs through a network, wherein the plurality of PDUs comprises a first group of one or more PDUs associated with an untagged domain, the method comprising the steps of: applying to the PDUs of the first

group entering the network a first VLAN tag comprising a first VLAN protocol identifier (VPIID) reserved for untagged PDUs; and applying to the PDUs of the first group with the first VLAN tag a second VLAN tag comprising a second VPIID; wherein the first VPIID and second VPIID are different;

- The claimed and/or described method, wherein the plurality of PDUs further comprises a second group of one or more PDUs associated with one or more VLAN domains; and wherein the method further comprises the step of applying to the PDUs of the second group entering the network a third VLAN tag, wherein the first VLAN tag and second VLAN tag are substantially the same;
- The claimed and/or described method, wherein the second VLAN tag is an 802.1Q tag and the second VPIID has a value of 0x8100;
- The claimed and/or described method, wherein the method further comprises the step of removing from the PDUs of the first group exiting the network both the first VLAN tag and the second VLAN tag;
- The claimed and/or described method, wherein the network is a metropolitan area network.

**[0027]** Although the description above contains many specifications, these should not be construed as limiting the scope of the invention but as merely providing illustrations of some of the presently preferred embodiments of this invention.

**[0028]** Therefore, the invention has been disclosed by way of example and not limitation, and reference should be made to the following claims to determine the scope of the present invention.

#### 40 Claims

1. A method for increasing a user virtual local area network (VLAN) space in a system adapted to transmit protocol data units (PDUs) received from at least a first network and a second network over shared communications links, wherein the first network comprises a first untagged domain and a first VLAN domain associated with a first VLAN identifier (VID) space, and the second network comprises a second untagged domain, the method comprising the steps of:

tagging one or more PDUs from the first untagged domain with a VLAN identifier conservation (VIC) tag comprising a VLAN identifier associated with the first network; and tagging one or more PDUs from the second untagged domain with a VLAN identifier conser-

vation (VIC) tag comprising a VLAN identifier associated with the second network.

2. The method of claim 1, wherein the VIC tag used for the first untagged domain and the second untagged domain further comprise a VLAN protocol identifier (VPID). 5
3. The method of claim 2, wherein one or more PDUs from the first VLAN comprises a VLAN tag comprising a VPID and a VID selected from the first VLAN space, and wherein the VPID of the VIC tag is different than the VPID of the VLAN tag. 10
4. The method of claim 3, wherein the VLAN tag and the VIC tag are 802.1Q tags. 15
5. The method of claim 4, wherein the VPID of the VLAN tag has a value of 0x8100. 20
6. The method of claim 5, wherein the PDUs comprising either the VLAN tag or the VIC tag further comprise an outer VLAN tag to tunnel the PDUs over the shared communications links. 25
7. The method of claim 1, in a first metropolitan area network (MAN) switch, wherein the first network is associated with a first customer network and the second network is associated with a second customer network. 30
8. The method of claim 7, wherein the VLAN identifier associated with the first customer network is a first customer identifier and the VLAN identifier associated with the second customer network is a second customer identifier. 35
9. The method of claim 7, wherein the second network comprises a second VLAN domain associated with a second VID space different than the first VID space. 40
10. The method of claim 9, wherein substantially all the PDUs from the first network and substantially all the PDUs from the second network are further tagged with a metro tag through a MAN. 45

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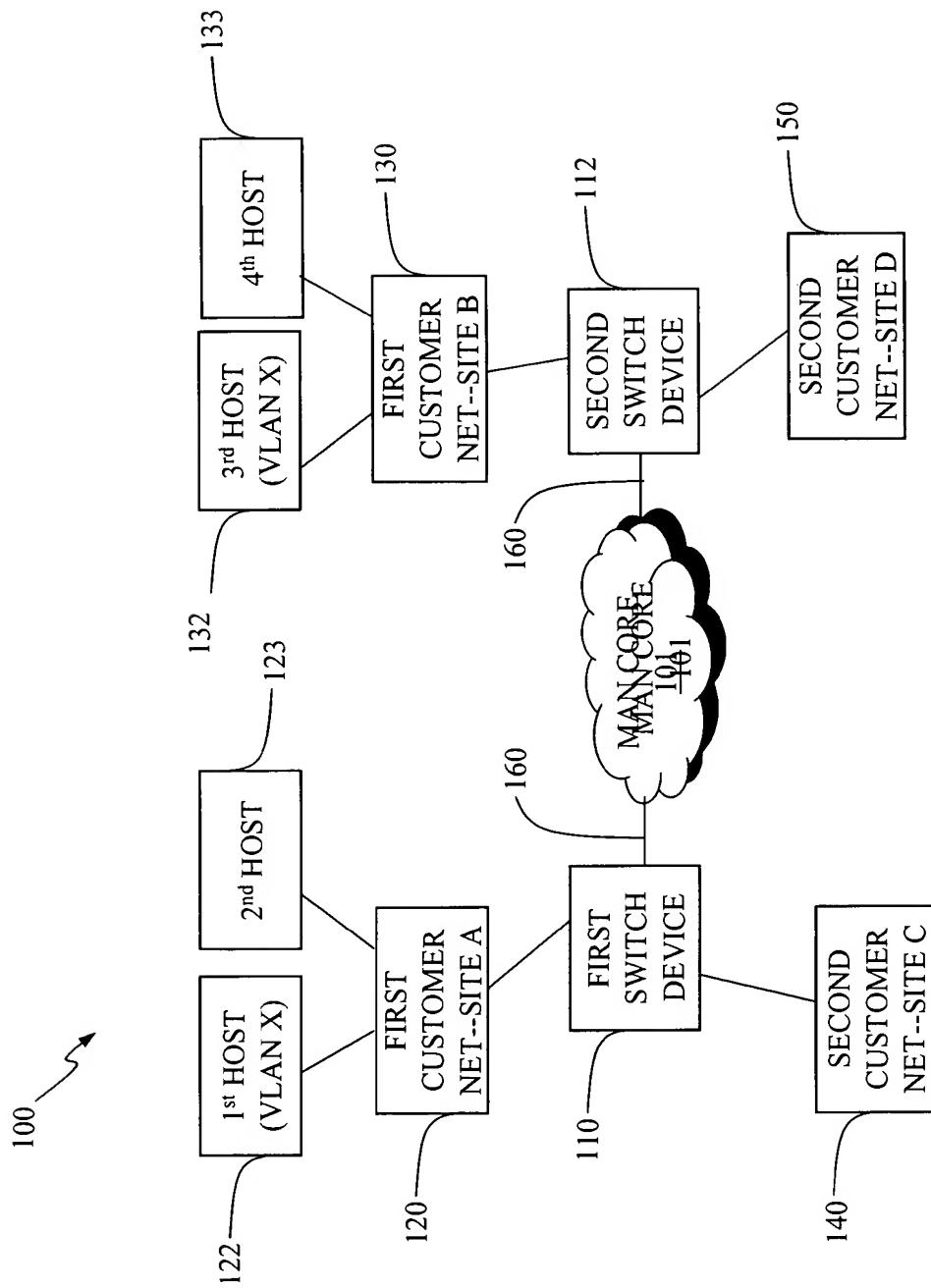


FIG. 1

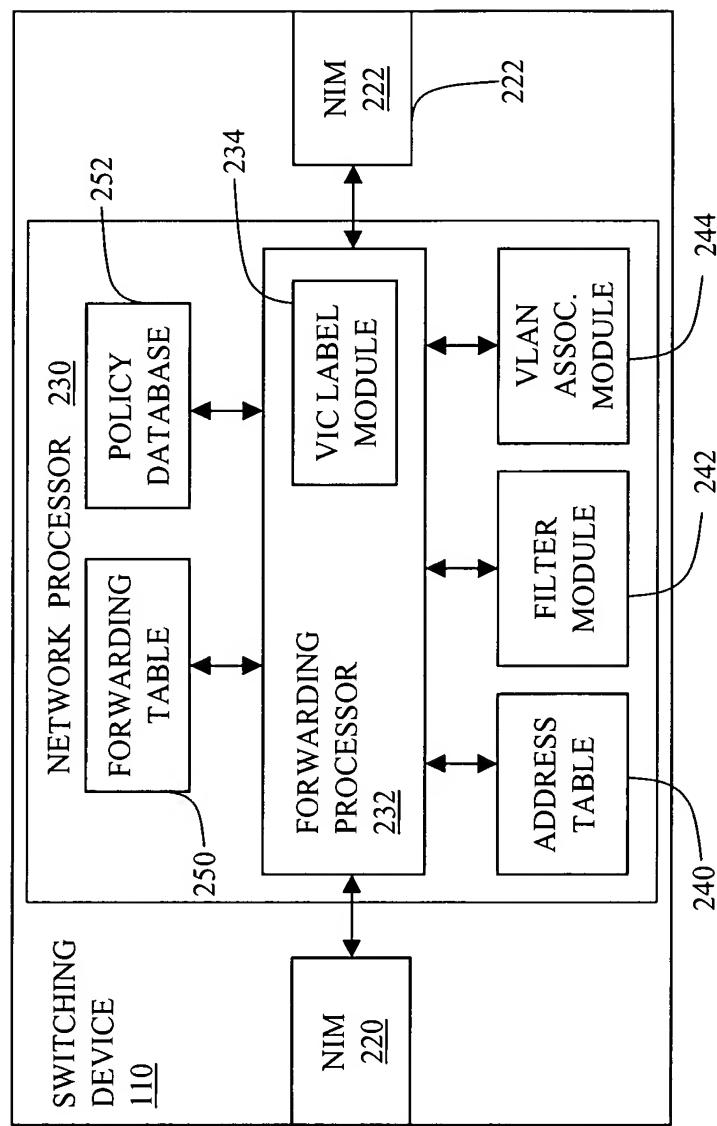


FIG. 2

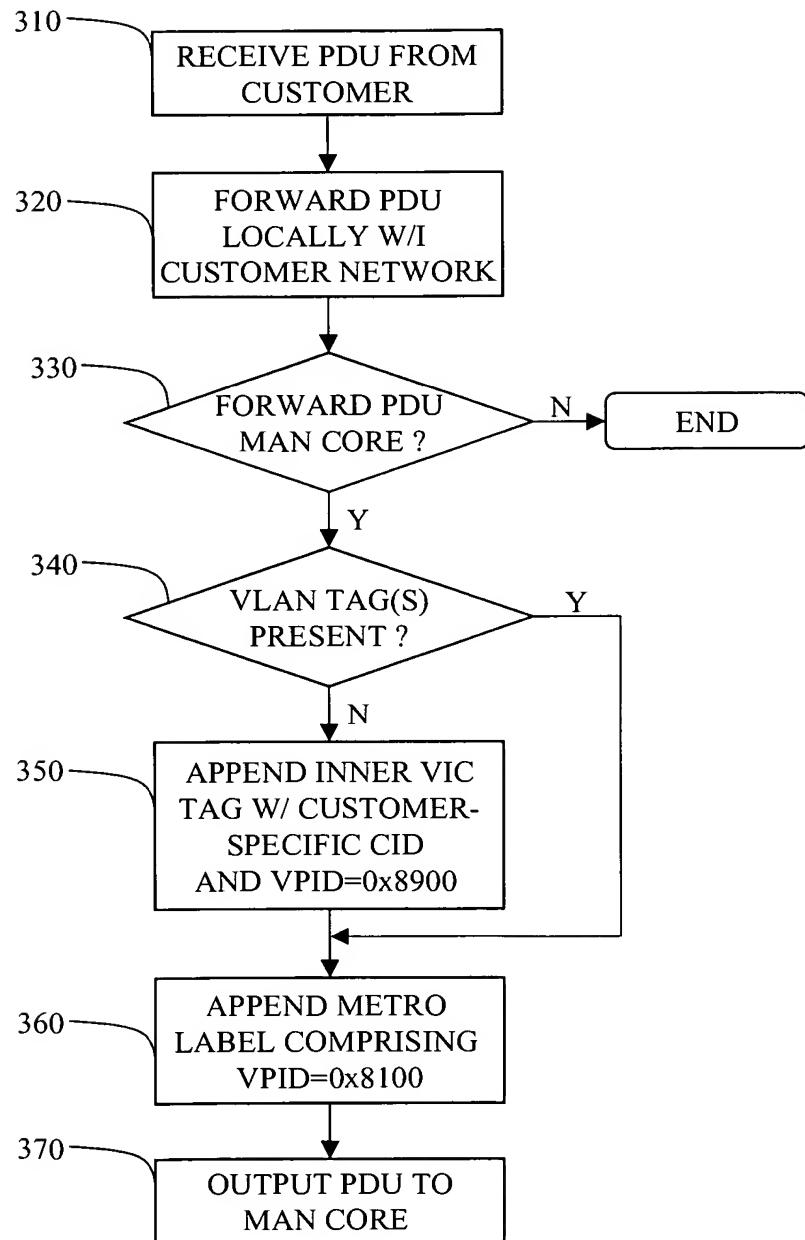


FIG. 3

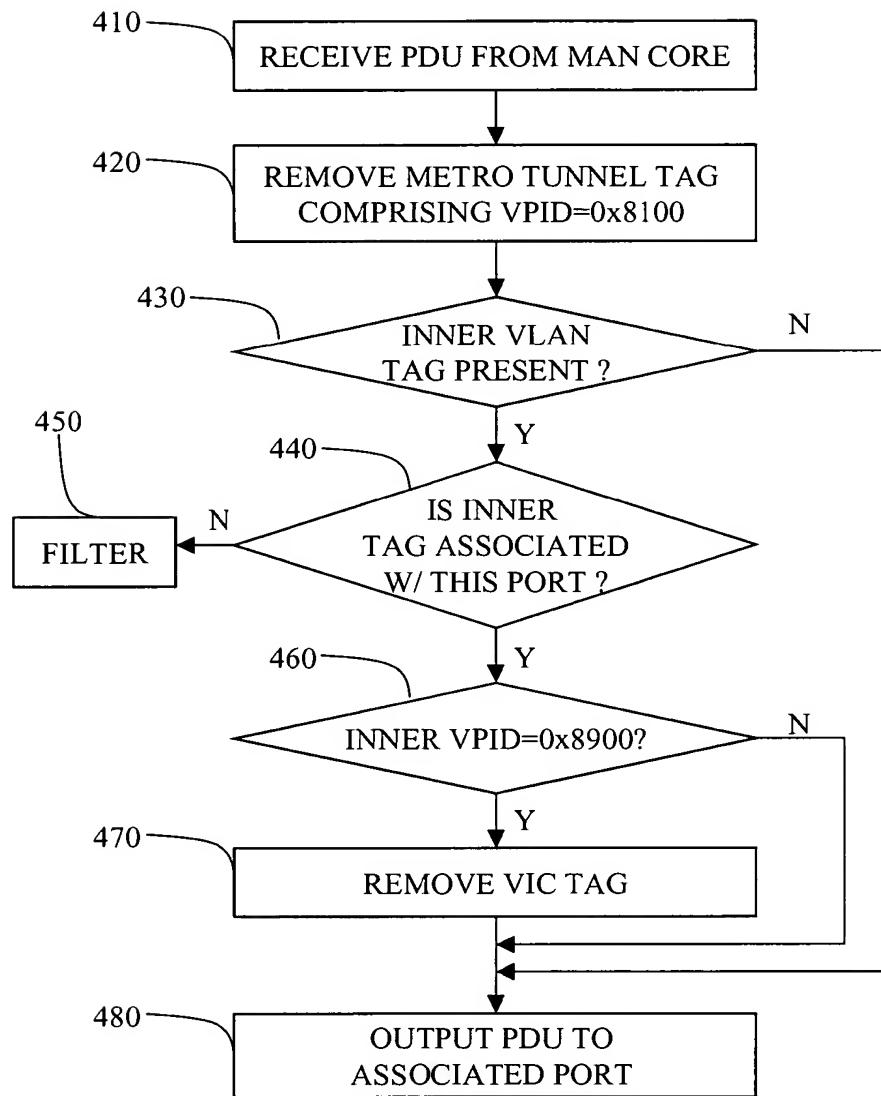
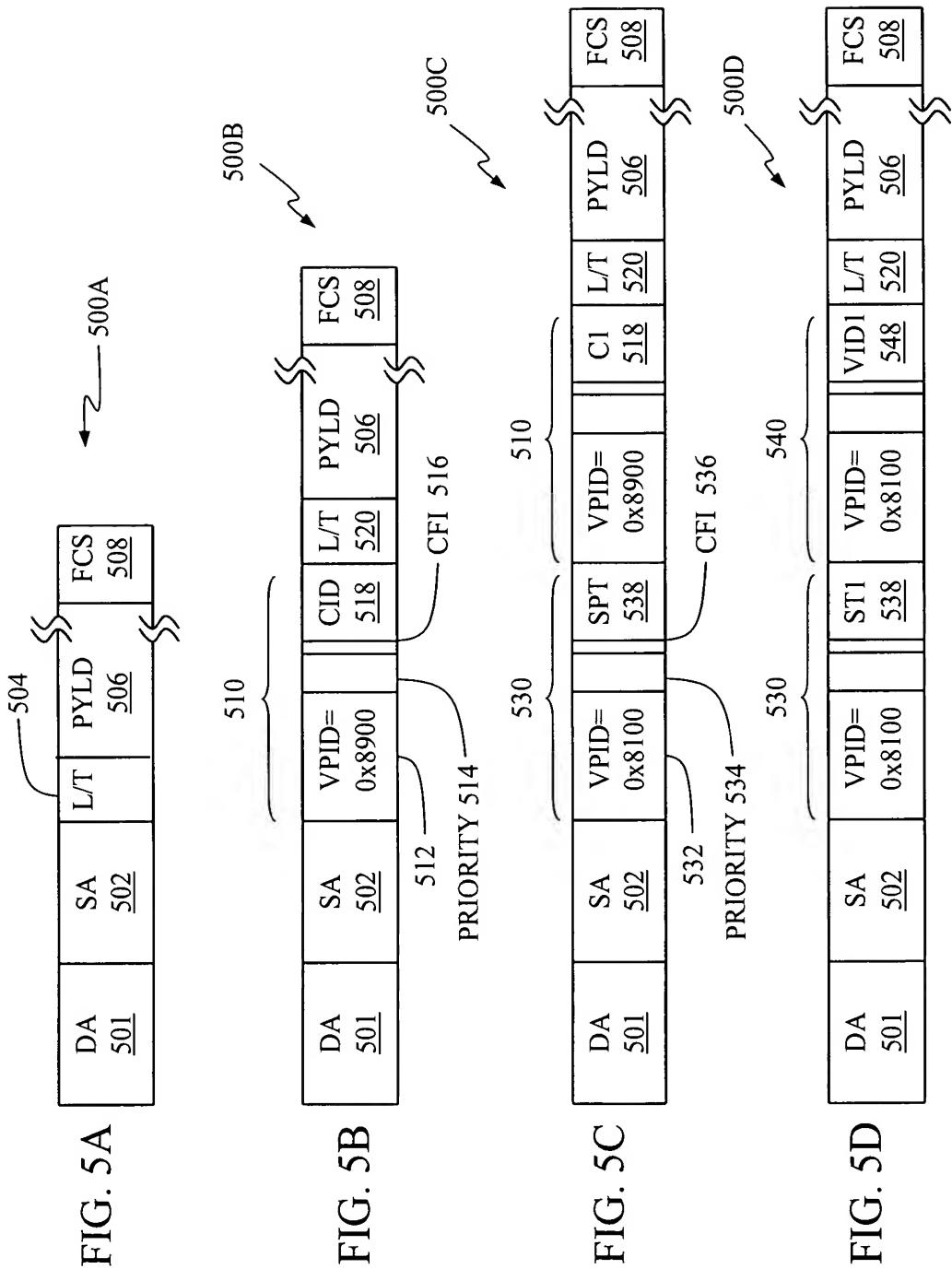


FIG. 4





European Patent  
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## EUROPEAN SEARCH REPORT

Application Number  
EP 04 02 9808

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| Category  | Citation of document with indication, where appropriate, of relevant passages   | Relevant to claim  |  |
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| The present search report has been drawn up for all claims  |   |  |  |
| 2   | Place of search<br><b>Munich</b>  | Date of completion of the search<br><b>16 March 2005</b> | Examiner<br><b>Plata-Andres, I</b>           |
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**ANNEX TO THE EUROPEAN SEARCH REPORT  
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**16-03-2005**

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